Batteries and Energy Storage Power Panel Discussion

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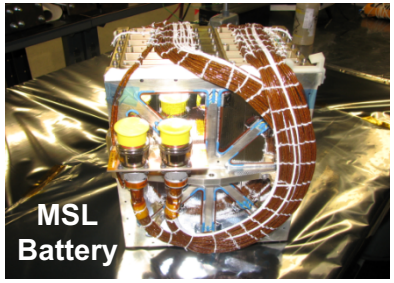
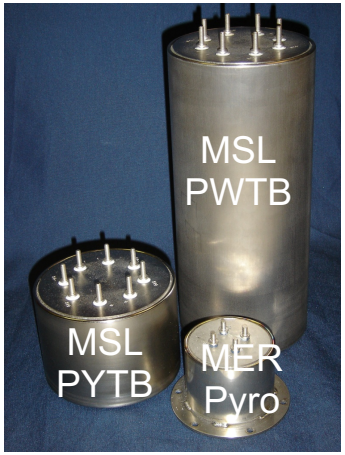
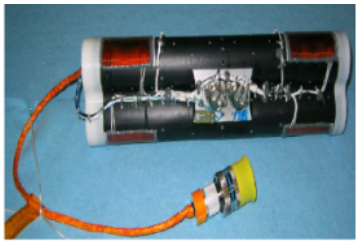
Most NASA Missions Require Batteries

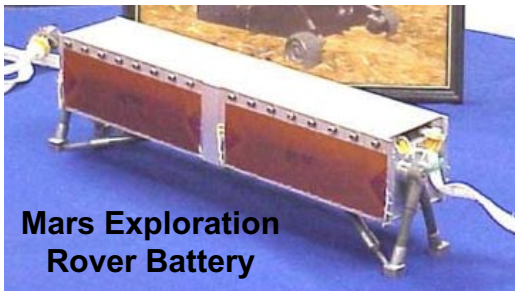




Thermal Batteries



Primary MER Battery

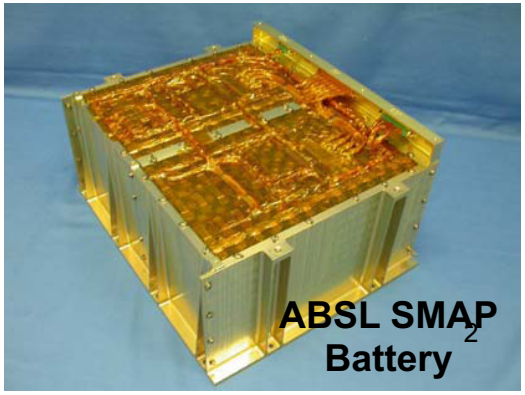


Li-ion cell battery housing

DS-2 ultra-low temperature primary cells

Low temperature cylindrical cells

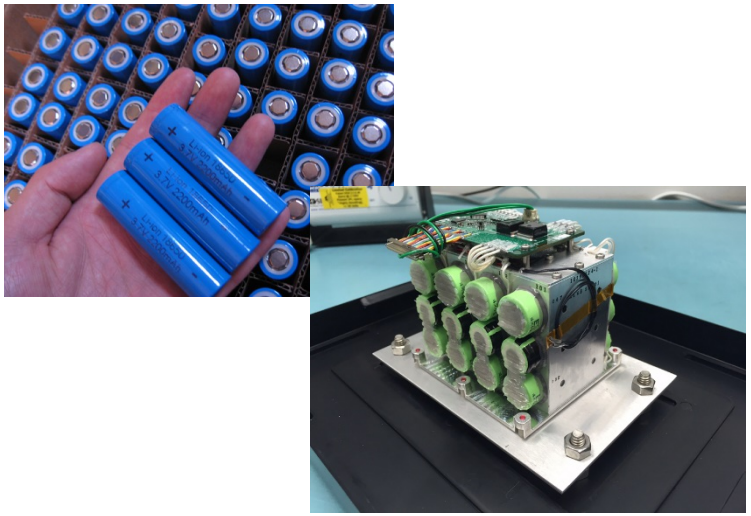
As a primary power source, to support load leveling or for operations involving eclipses/night operations



Main Cell Types Used For NASA Missions

- **Battery is comprised of multiple cells**
  - Add cells in series to increase voltage
  - Add cells in parallel to increase capacity
- **Lithium-ion cell types used for planetary exploration**
  - Large Prismatic Cells (Yardney, GS Yuasha): 5 to 190 Amp-hour capacity
  - Small Cylindrical Cells (Sony, Panasonic): 2-3 Amp-hour capacity
- **Primary Cells are typically D or larger size**
  - D or DD Cylindrical Cells (Saft, EaglePicher): 10-20 Amp-hour capacity

Rechargeable Li-ion Prismatic Cells



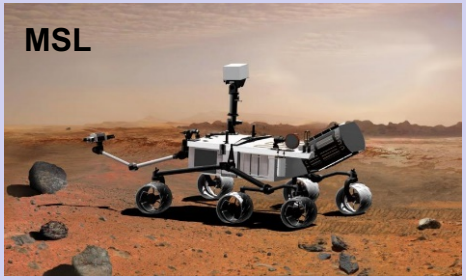
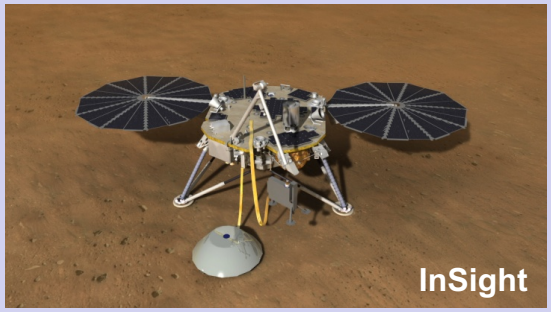
Rechargeable Li-ion Cylindrical Cells

Primary Li Cylindrical Cells

Battery Design Approach Starts with System Analysis

- What loads are involved and what power levels are required?
- How much energy is required per cycle?
- What is the operating environment?
- What options are available for thermal management?
  - Low temperature performance (heaters, radioisotope heaters)
  - High temperature resilience (radiators, louvers)

Environment, Thermal Management Dictate Approach

Missions where adequate thermal management is available	Missions where wider operating temperatures provide system benefits	Missions where wide temperature operation is critical
Examples • RTG heat available • Avionics waste heat available • Inherent heat generation from cells based on cell chemistry	**Examples** • System design benefits from wider temperature limits • Some non-resistive heat available (RHUs)	**Examples** • Small augmentation missions • Very small mass, volume budgets • Little room, power for heaters, or RHUs are cost prohibitive
  High specific energy and long life takes precedence	  Design of electrolytes has largest influence on low temperature performance and high temperature resilience	  

Decreasing thermal management options and increasing battery customization